Joint Center for Satellite Data Assimilation

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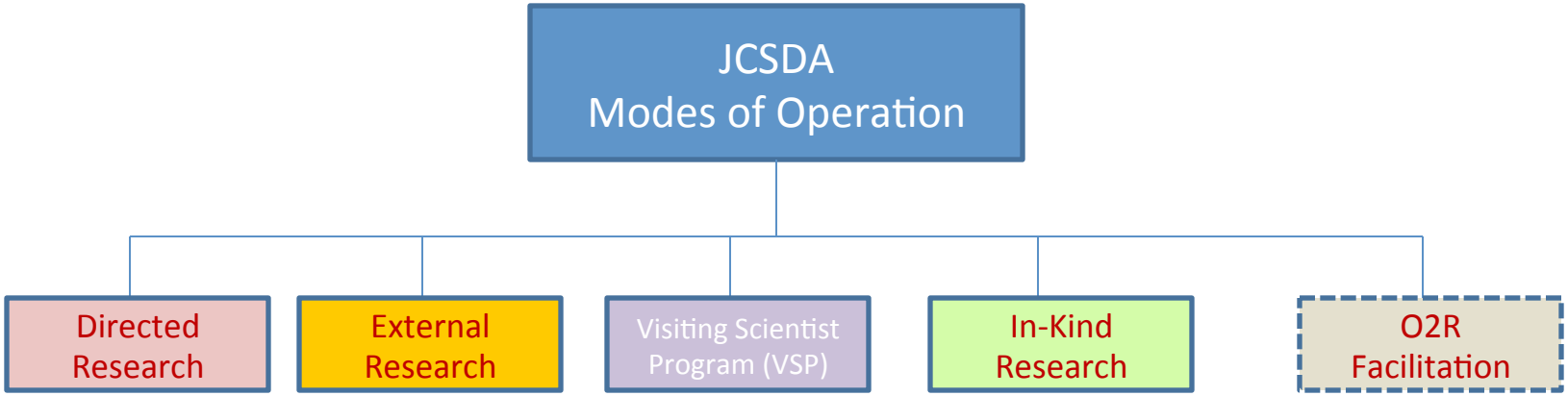
Outline

1. Background and Introduction
2. Science Priorities
3. Project Selection and Management
4. FY14 Major Accomplishments
5. FY15 Major Activities

Background & Introduction



- Directed by JCSDA affiliated scientists

-Example of DRT between NESDIS and NWS

-Carried out by the partners

- Mixture of new and leveraged funding

- Short-term ROI expected

- Grants and/or contracts awarded

- Administered alternately by NOAA, NASA with contribution from DoD)

- Open to the broader research community

- Funding awarded competitively

- Near-term ROI expected

-Great way to initiate/strengthen involvement with JCSCA

-Open to scientists from everywhere

-Short-term (a few weeks/months)

- Requires to Identify host at partner institution; work on JCSDA-relevant topic

- Mid-term ROI expected

- Research undertaken independently by partners, overlapping with JCSDA priorities

-Results/deliverable are made available and shared with/ between partners

- JCSDA mainly coordinates

- Offers O2R environment

-Open to External scientists, even not funded by JCSDA

-Goal: funnel efforts toward helping the JCSDA partners (incl. NOAA)

- Carrot is access to HPC & operational systems in R&D

- S4 and JIBB

JCSDA Science Priorities

Overarching goal: Help the operational services improve the quality of their prediction products via improved and accelerated use of satellite data and related research

- Radiative Transfer Modeling (CRTM)
- Preparation for assimilation of data from new instruments
- Clouds and precipitation
- Assimilation of land surface observations
- Assimilation of ocean surface observations
- Atmospheric composition; chemistry and aerosol

Approved by the Science Steering Committee

Selection of Base Projects

Category	Activity	Outcome	Beneficiaries	Comments
Science & Advanced Data Assimilation	- Scientific/technical Support to CRTM - Spectroscopy Improvements (including LBL modernization) - Cloudy radiance assimilation - Optimize DA of microwave sounders and imagers (ATMS, SSMIS, AMSU, MHS,..) - Land Data Assimilation - Ocean data Assimilation	- Improved CRTM - **Modern LBL model (in progress)** - **ATMS, AMSU, MHS, SSMIS** - GPM, AMSR2, Imaging channels - **SMAP** - AHVRR/MODIS/VIIRS GVF - Jason-2/3	- All (inc. NWS, NESDIS)	
Tools	- Multi-Platform QC and Pre-Processing Tool (MIIDAPS) - Community Multi-Formatting Tool (CMFT) - Community Sampling Thinning & Representativeness Optimization Tool (CSTROT)	- Universal QC tool and Pre-processor for all satellite data -For BUFrizing all sat. data	- All partners (inc. NESDIS, NWS) - All (esp. academia and ext. research partners)	
New Sensors	- Geo DA: **Himawari-8 Assimilation, GOES-R ABI Readiness** -Microwave sensors: **GPM** GMI, GCOM-W AMSR-2	-On-going effort.	-NESDIS -NWS	
O2R Environment Extension	- **Extend O2R to GDAS T1534, 4DHybrid** - Extend O2R to HWRF, etc	-Allow Science activities to be using the most up to date version - Allow more systems to be improved - Helps the R2O process - Increase ROI of NESDIS projects	- NWS - NESDIS	

HDRA 2013 (Sandy) JCSDA Activities

Category	Activity	Outcome	Beneficiaries	Comments
Science & Advanced Data Assimilation	- AMV Data Assimilation Improvement - Cloudy Radiance Data Assimilation - Geostationary Radiance Assimilation Improvement - SSMIS Data Assimilation Optimization - Land Data Assimilation - Ocean data Assimilation	- Improved CRTM - Modern LBL model (in progress) - Assimilation of: ATMS, AMSU, MHS, SSMIS, GPM, AMSR2, Imaging channels, SMAP, AHVRR/MODIS/VIIRS GVF, Jason-2/3 (on going effort) - Mitigate the effect of the potential loss of the PM orbit (on going)	- All (inc. NWS, NESDIS)	
New Sensors & OSSE	- OSSE Activities (Geo Hyperspectral, Radio Occultation)	-On-going effort. -Assess future sensors configuration (Radio Occultation sensors, Hyperspectral Sensor on Geo)	-NESDIS -NWS -OAR	
O2R Environment Extension	- Upgrade/extend the JIBB and S4 supercomputers	-Double capacity of the JCSDA HPC - Allow highest resolutions systems to be worked on	- NWS - NESDIS - OAR	

Selection of External Research

Selected Projects through the NOAA Federally-Funded Opportunity (FFO) –FY13

Project #	Proposal Number(s)	Title	Institution	PI
1	12,10	Modernization of the Community line-by-line models and CRTM-OSS Implementation	Atmospheric & Environmental Research (AER)	Jean-Luc Moncet, PI Eli Mlawer, co-PI
2	15	Improvement and validation of JCSDA's Community Radiative Transfer Model (CRTM) Optical Properties	Texas A&M University	Ping Yang, PI
3	4	Evaluation and Improvement of Land Surface States and Parameters to Increase Assimilation of Surface-Sensitive Channels and Improve Operational Forecast Skill	University Corporation for Atmospheric Research	Michael Barlage, PI Xubin Zeng, co-PI
4	5	Assimilation of All-Sky Microwave and Infrared Satellite radiances: from research to Operations	National Center for Atmospheric Research University of Wisconsin, Cooperative Institute for Meteorological Satellite Studies	Thomas Auligne, PI

The FY15 External Research Opportunity:

- Selection in progress.

- Target Start date: August 2015.

The upcoming JCSDA newsletter will highlight all JCSDA external research projects, pre-faced by T. Lee (NASA) and S. Boukabara (NOAA)

Selection of Visiting Scientists at JCSDA-NOAA (FY14 Cycle)

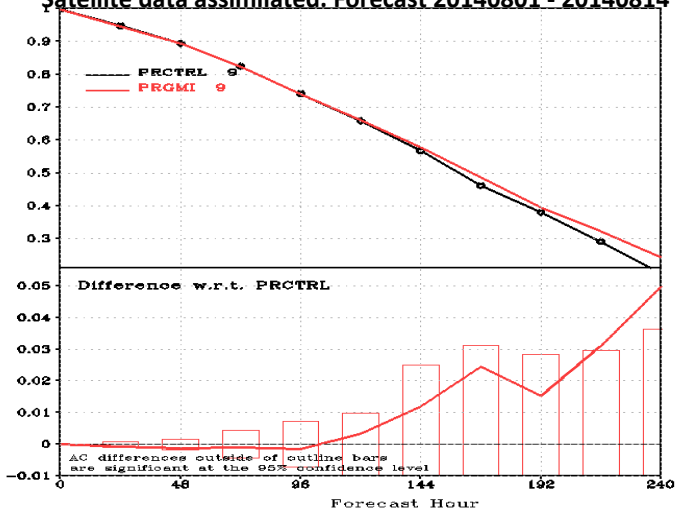
Visit (Title)	Host Institution (Beneficiary)	Area of benefit	V. Scientist Parent Institution
Migration of a wind-wave data assimilation scheme to NOAA systems	NWS	Ocean Data Assimilation	Naval Service, Argentina
HYBRID data assimilation for the Indian Ocean	NWS	Ocean Data Assimilation	Indian Met. Service (India)
Exploring Mathematical cutting edge techniques in satellite data assimilation	NESDIS	CRTM & Inversion In Cloudy/Precipitating Conditions	Georgetown University (US)

GMI Data Assimilation

(Preliminary but Encouraging Results)

- JCSDA began optimizing the assimilation of GMI data in GDAS.
  - A new QC subroutine has been developed to filter out cloud and precipitation contaminated observations from GMI data for clear sky data assimilation.
  - Bias correction, observation errors, and QC routines continue to be optimized, and forecast impacts are being assessed.

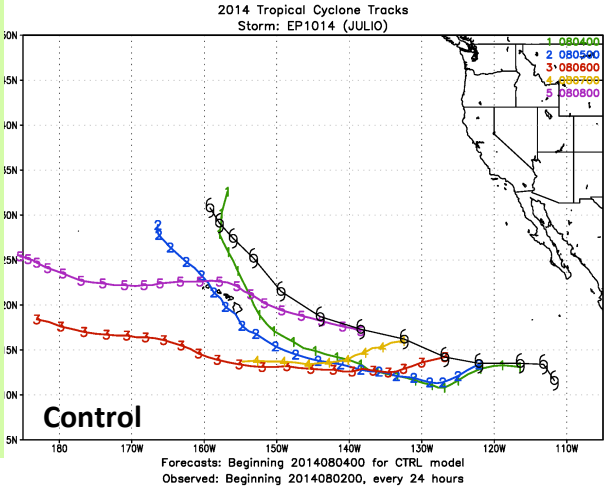
Anomaly Correlation 850 hPa Wind, N. Hemisphere:
Satellite data assimilated. Forecast 20140801 - 20140814

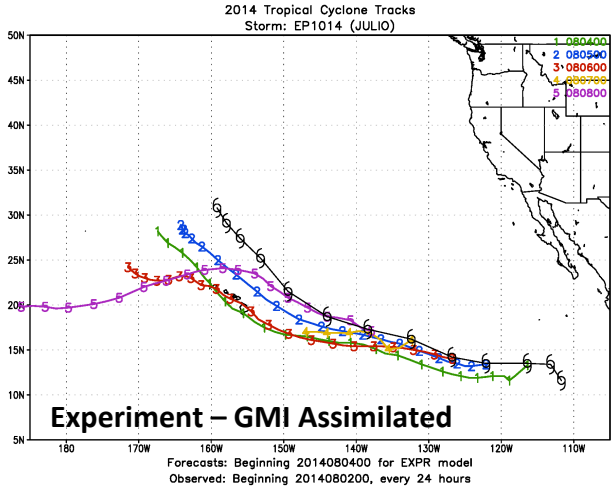


Preliminary assessment shows the assimilation of GMI data changing forecast hurricane tracks and the skill scores of forecast variables.

- Results are mixed, sample sizes thus far have been small.
- Work is ongoing to isolate and qualify forecast impacts.

Forecast Hurricane Tracks, Hurricane Julio, with and without GMI Assimilated:
No satellite data assimilated. Forecast period 20140804 - 20140808

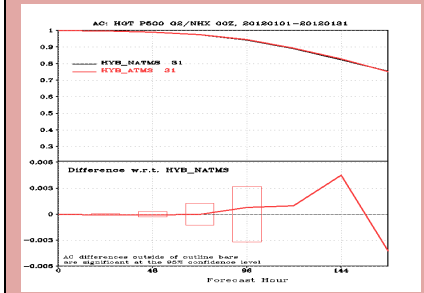




SNPP ATMS Assimilation Optimization

Current Assimilation

- **S-NPP ATMS assimilated operationally at NCEP since May 2012 GDAS/GFS upgrade (L+6 months)**
- **Next generation MW sounder should have some positive impact on NWP forecast.**
  - Additional channels (1 51 GHz, 2 183 GHz)
  - Scan geometry (Nyquist sampling, wider swath)



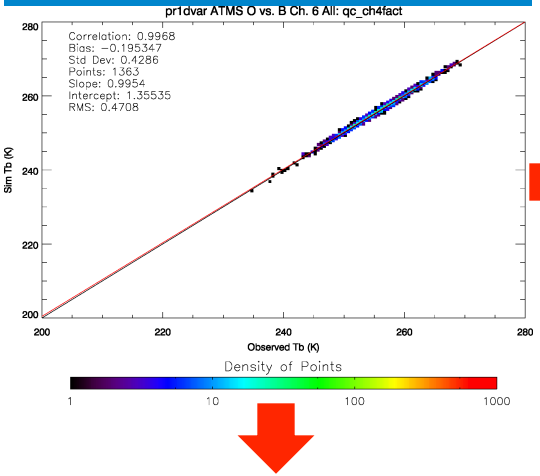
Forecasts with ATMS (and no AMSU) show similar performance to forecasts with no ATMS (with AMSU)

Assimilation Improvements

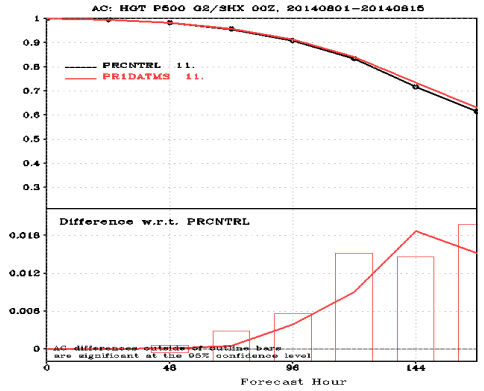
- **Enhance data thinning/data selection from coarse (skip 5 out of every 6 FOVs) to intelligent thinning (CSTROT).**
- **Optimize spatial averaging (maintain high resolution for sounding/water vapor channels).**
- ***Implement dedicated ATMS Quality Control routine based on 1DVAR preprocessor to increase the number and quality of assimmilated observations.***

Optimization Results

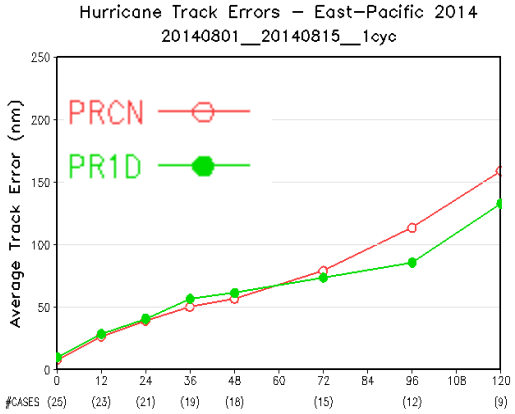
10% more observations per sounding channel, per cycle, with new QC



Statistically significant increase in SH Anomaly Correlation (500 mb). Neutral NH.



Reduction in Tropical Cyclone Track Forecast Error



SSMI/S Assimilation Optimization

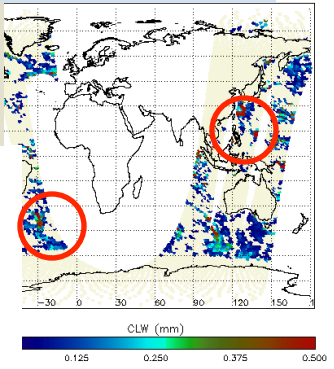
Current Assimilation

- **DMSP SSMI/S on-board 4 platforms (F16, F17, F18, F19) in early morning polar orbit**
  - F16 sounding channels failed
  - F19 available Q1 FY15
- **2015 NCEP GDAS/GFS upgrade will assimilate temperature sounding channels**
  - No imaging/water vapor channels assimilated
- **Forecast impact from SSMI/S is neutral**
- **Work in progress to extend to DMSP F19**

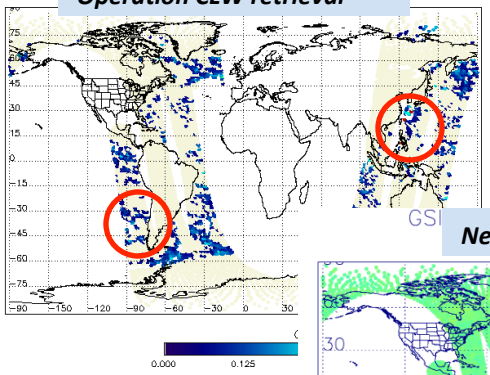
Optimization Approach (2016 GDAS/GFS Upgrade)

New liquid and ice cloud retrieval algorithms, and removal of precipitation pre-screening.

New CLW Retrieval

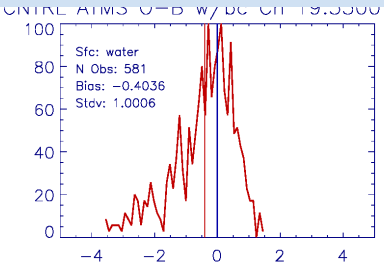


Operation CLW retrieval

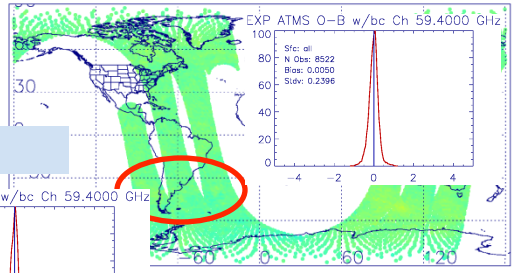


Just 500 observations over ocean passing QC but not assimilated for imaging 19 GHz

Current SSMIS 19 GHz O-B

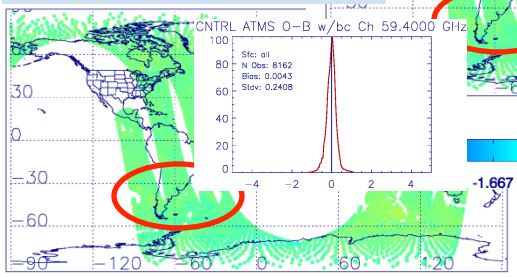


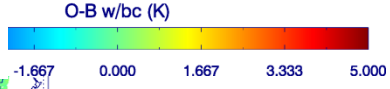
New SSMIS 55 GHz O-B

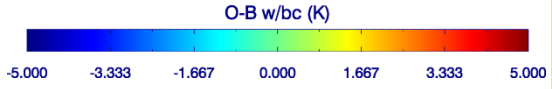


Characterize SSMIS imaging channel bias and error for application in GSI

Current SSMIS 55 GHz O-B

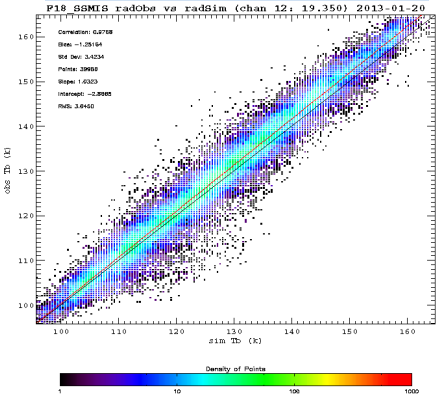






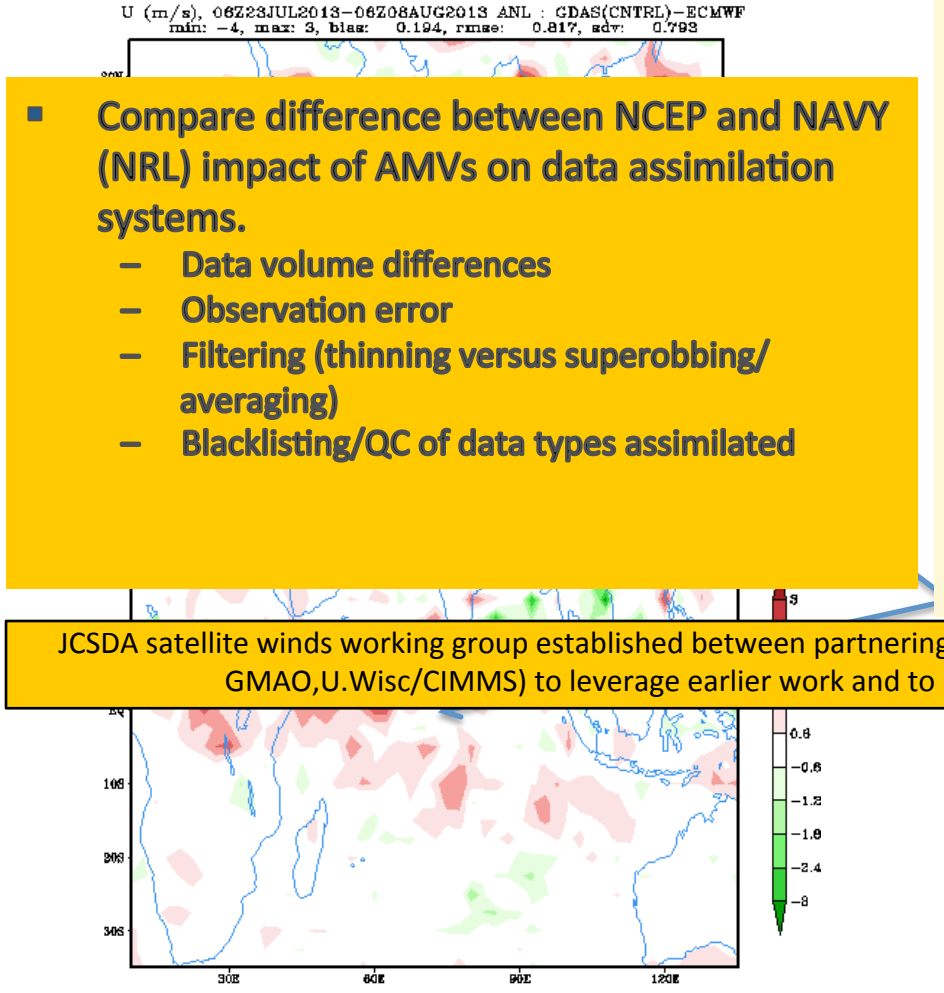
Better QC leads to more middle/upper tropospheric observations being assimilated (400 more obs for this cycle)

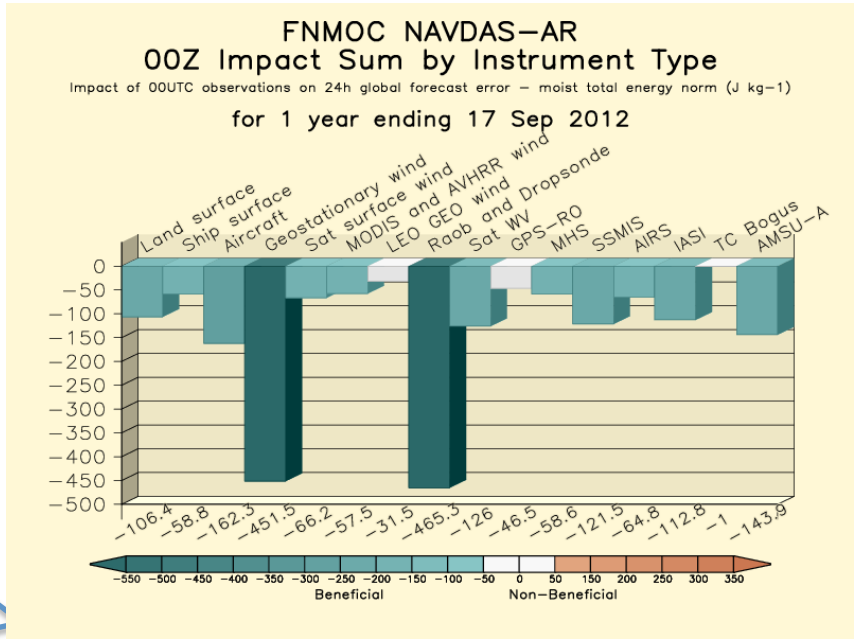
SSMIS 19 GHz Obs vs Sim



AMV Data Assimilation Optimization

- Compare difference between NCEP and NAVY (NRL) impact of AMVs on data assimilation systems.
  - Data volume differences
  - Observation error
  - Filtering (thinning versus superobbing/ averaging)
  - Blacklisting/QC of data types assimilated





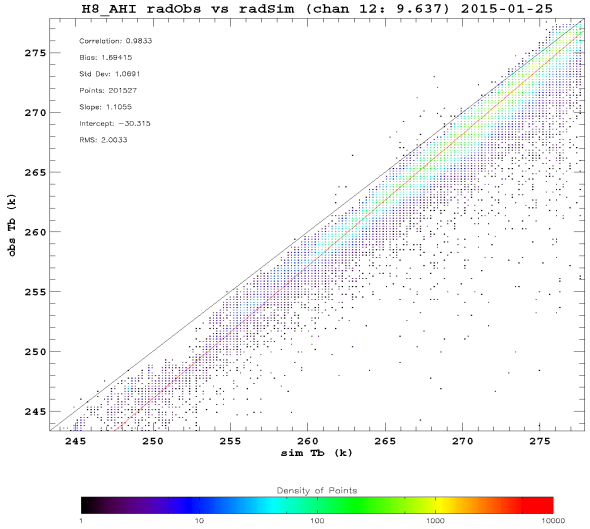
JCSDA satellite winds working group established between partnering agencies (NESDIS/JCSDA, NCEP/EMC, NAVY/NRL, NASA/ GMAO,U.Wisc/CIMMS) to leverage earlier work and to improve AMV assimilation across the board.

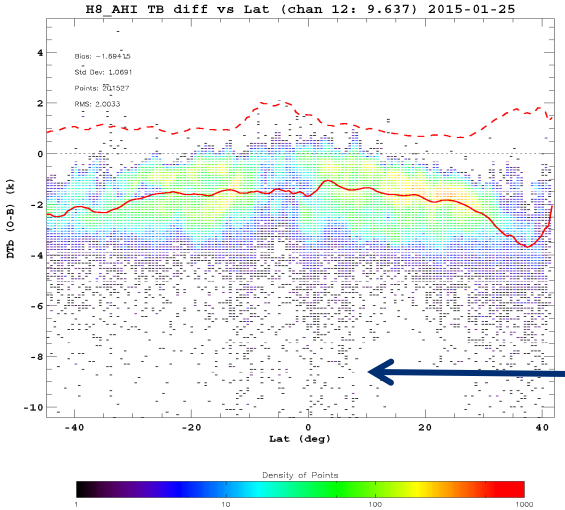
GDAS analysis is improved with respect to ECMWF analysis in the region of the Tropical Easterly Jet (TEJ).

Plans: Continue optimization of AMV observation errors, filtering, data usage and investigate regional and global analysis and forecast skill within the GSI/GFS.

Assessment of AHI H8 sample data

(GOES-R Readiness)





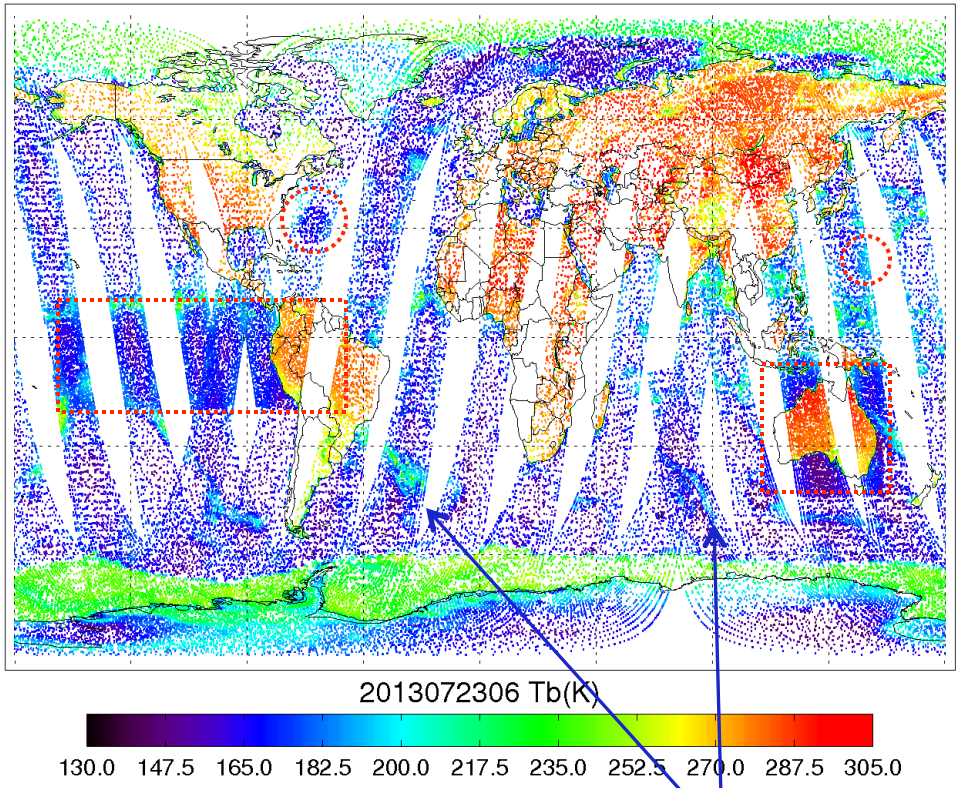
H8 AHI All Clear-Sky Cases (Ocean Only)

Chan	Freq, [μm]	Bias, [K]	Std. Dev., [K]	RMSE, [K]	Corr.	No of Cases
7	3.885	0.25	1.96	1.97	0.87739	201526
8	6.243	-0.88	1.43	1.68	0.95798	201527
9	6.941	-1.11	1.41	1.79	0.96555	201527
10	7.347	-1.53	1.17	1.93	0.96809	201527
11	8.593	-1.92	1.10	2.21	0.93832	201527
12	9.637	-1.69	1.07	2.00	0.98338	201527
13	10.407	-2.14	1.04	2.38	0.93697	201527
14	11.240	-2.36	1.22	2.66	0.90823	201527
15	12.381	-3.08	1.49	3.42	0.87424	201527
16	13.281	-4.13	1.19	4.30	0.91985	201527

- BUFR observations (courtesy of W. Wolf, NESDIS, Y. Song, IMSG) from JMA's 2015-01-25 full disk sample is thinned by selecting every 10th point ~ 20km spacing between 2km pixels.
- Clear-sky filtering using a threshold of 1.25K in the difference between a split-window simulated regression SST and NWP (ECMWF) SST.
  - Viewing angle restricted to be within 55^{o} of nadir.
  - Roughly 10% of thinned pixels over ocean are determined to be clear; however, some residual cloud remains.

Community Satellite data Thinning and Representation Optimization Tool (CSTROT)

Thinning of AMSU-A (N15+N19+Metop-A) Ch-2 Tb
(0006 UTC 23 July, 2013)



Specified

Two target regions

Two domain areas

Auto detected

Higher density in higher variation regions associated with cloudy, frontal system, moisture tongue.

❖ Objective of CSTROT:

➢ Develop a new thinning scheme to optimize satellite data usage in GSI data assimilation for both global and regional modeling systems.

❖ CSTROT Functions:

➢ Thinning options:

- using Standard Deviation
- using regression
- by skipping points

➢ Representation options:

- Random points
- Closest point
- Averaging

➢ Nested domain options:

- by target regions
- by domain size

The tool will allow an optimal information content extraction while optimizing computation time

CSTROT is an "intelligent" thinning tool to optimize satellite data selection in DA.

OSSE Activities
Hypothetical Sensors

- **Sponsor-funded OSSE activities were undertaken in JCSDA:**
  - Wind Lidar OSSE effort funded by NASA
  - Hyperspectral Geo sensor OSSE funded by NESDIS
  - DoD-requested OSSE in support of DMSP-follow on decision making (DWSS)

- **OSSE activity has been initiated in NOAA. JCSDA in leading role**
  - In support of H. Sandy funded data gap mitigation strategy
  - Goals to achieve:
    - (1) set up the next generation OSSE tool (newest data assimilation system, higher spatial resolution, new NR, etc)
    - (2) Provide authoritative evaluations on the impact of Geo-based hyperspectral sensors and Radio Occultation sensors (multiple commercial options), Geo-based MW sensor on NOAA systems

- **Effort is well coordinated with QOSAP initiative**
  - Main focus of JCSDA is global experiments
  - Coordination ongoing with AOML, ESRL, CIMMS, etc

Impact Assessment of JPSS Data Gap

The launch of JPSS-1 will occur past the design life of heritage passive microwave and infrared atmospheric sounders on the current POES and Suomi-NPP platforms.

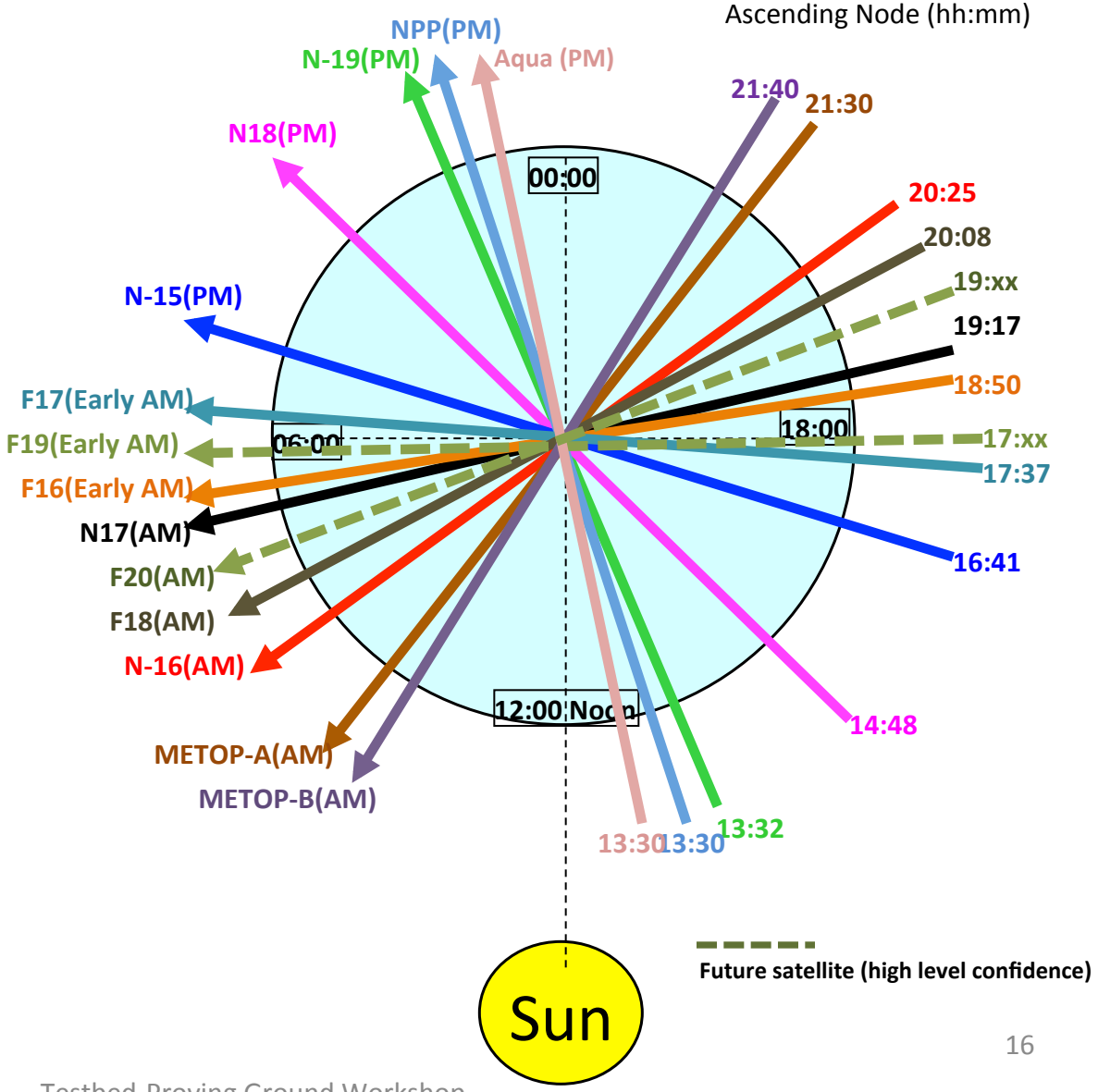
A new set of "Data Denial" experiments are being run to assess the expected forecast impact if no Afternoon, polar-orbiting satellite data is available due to the data gap.

The "Control" experiment establishes baseline performance of the current satellite observing system capability.

The "3polar" experiment removes the redundancy of observations but maintains platforms flying in early-morning, mid-morning, and afternooon polar orbits.

The "2polar" experiment removes the redundancy of observations plus all platforms flying in the afternoon polar orbit (the data gap).

The "1polar" experiment removes the redundancy of observations plus both the early-morning and afternoon polar orbits (leaving only mid-morning observations).



Constellation as of September 2012. Sources: NESDIS/OSO & CGMS/WMO pages

Impact Assessment of JPSS Data Gap

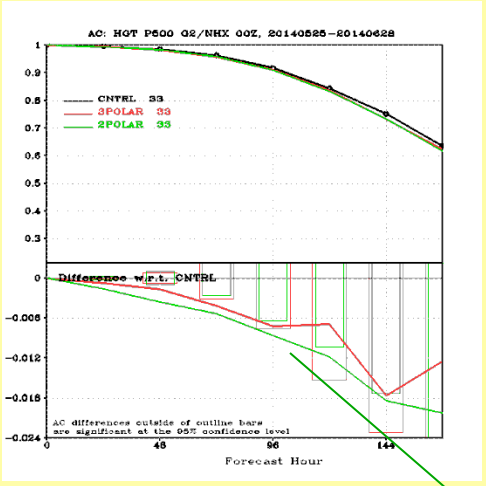
Experiments

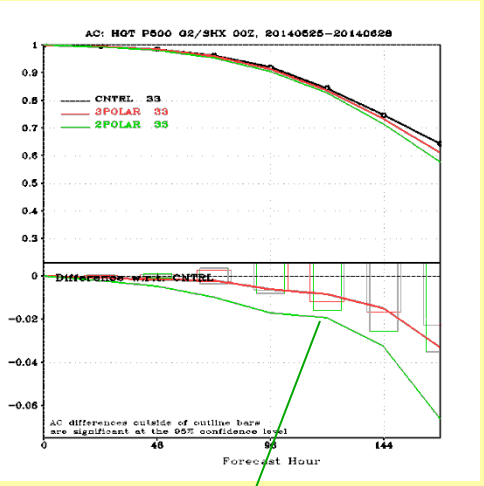
- **Current operational GDAS/GFS (T574/ T1534 resolution)**
- **1 Season: May 15, 2014 - July 31, 2014**
- **4 experiments:**
  - Control run
  - 3 polar
  - 2 polar (data gap)
  - 1 polar

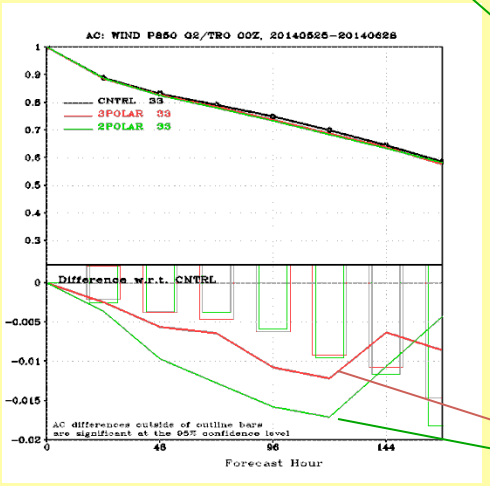
Status

- **All experiments processed May 15 – July 3, 2014.**
- ***Preliminary results are showing expected degradation of forecast performance from Control to 3polar to 2polar experiments.***
- ***Degradation from Control to 3polar suggests current observing system is not completely redundant.***
- ***We will extend the experiments to independently verify impact of Individual Obs Systems***

Anomaly Correlation







2polar degraded beyond significance interval.

TOP: 500 mb AC dieoff curves for Northern Hemisphere (left) and Southern Hemisphere (right).

LEFT: 850 mb Wind AC dieoff curves over the tropics.

3polar and 2polar degraded beyond significance interval.

Planned FY15 Priorities

Category	Planned FY15 Activities	Expected Outcome	Availability of Resources	Comments
High Priority Baseline Activities	- CRTM - Passive Microwave Sounders DA - Passive Microwave Imagers DA - Radio Occultation - Land Data Assimilation - Ocean data Assimilation - Aerosols DA - Ozone DA	- Improved CRTM - ATMS, AMSU, MHS, SSMIS - **GPM**, AMSR2, Imaging channels - **SMAP** - Jason-2/3 - SNPP VIIRS - **SNPP OMPS**	- Yes (Base)	- This is the main directed research program in JCSDA -Hard choices must be made to accommodate other priorities - Reduction of support expected
New Sensors	- **Megha-Tropiques SAPHIR** - **HIMAWARI – AHI8** - **OCO-2** - **ISS-RapiSCAT**	-Improvement in Upper WV skills *(Meteo-France info., see EUMETSAT conf.)* -Increase readiness **GOES-R ABI** - Explore use of Sfc Pressure globally - Surface Wind speed	-No (best effort to fold it under passive microwave DA efforts) - Yes (H. Sandy effort) - No (best effort to fold it under IR DA efforts) - Yes (under active sensors DA)	
Impact Assessments	- Initial implementation of **JOSASC** Initiative - Data Gap Impact assessment & mitigation effort impact assessment	-Ability to assess impact of GOS in hurricane conditions and at global scale - Better readiness for a data gap situation. Evaluate the impact of the added value.	- No but funds to be carved out from JCSDA and QOSAP to seed-fund it - Yes (H. Sandy) - Would require sustained HPC and funding for future years	- This would be at the expense of other baseline activities
Support the Data Gap Mitigation effort (H. Sandy funding)	- AMV Data Assimilation (cont'd) - Cloudy Radiance assimilation - Geo radiance data assimil. - OSSE experiments	-Mitigate the impact of losing the PM orbit - Evaluate options for future instruments	- Yes (H. Sandy)	

Aerosols Data Assimilation Coordination

Improving NCEP global aerosol forecasts using JPSS S-NPP VIIRS aerosol products

The Scope of the Project

NOAA Model

NEMS GFS Aerosol Component (NGAC)

Satellite Observations

Aerosol observations from S-NPP VIIRS

first guess

input observations

NOAA DA System

The hybrid EnKF-GSI system

New Capability to assimilate aerosol optical depth (AOD) observations

NOAA Products

New Product: Aerosol analysis for multi-species

Improve real-time NGAC aerosol forecasts

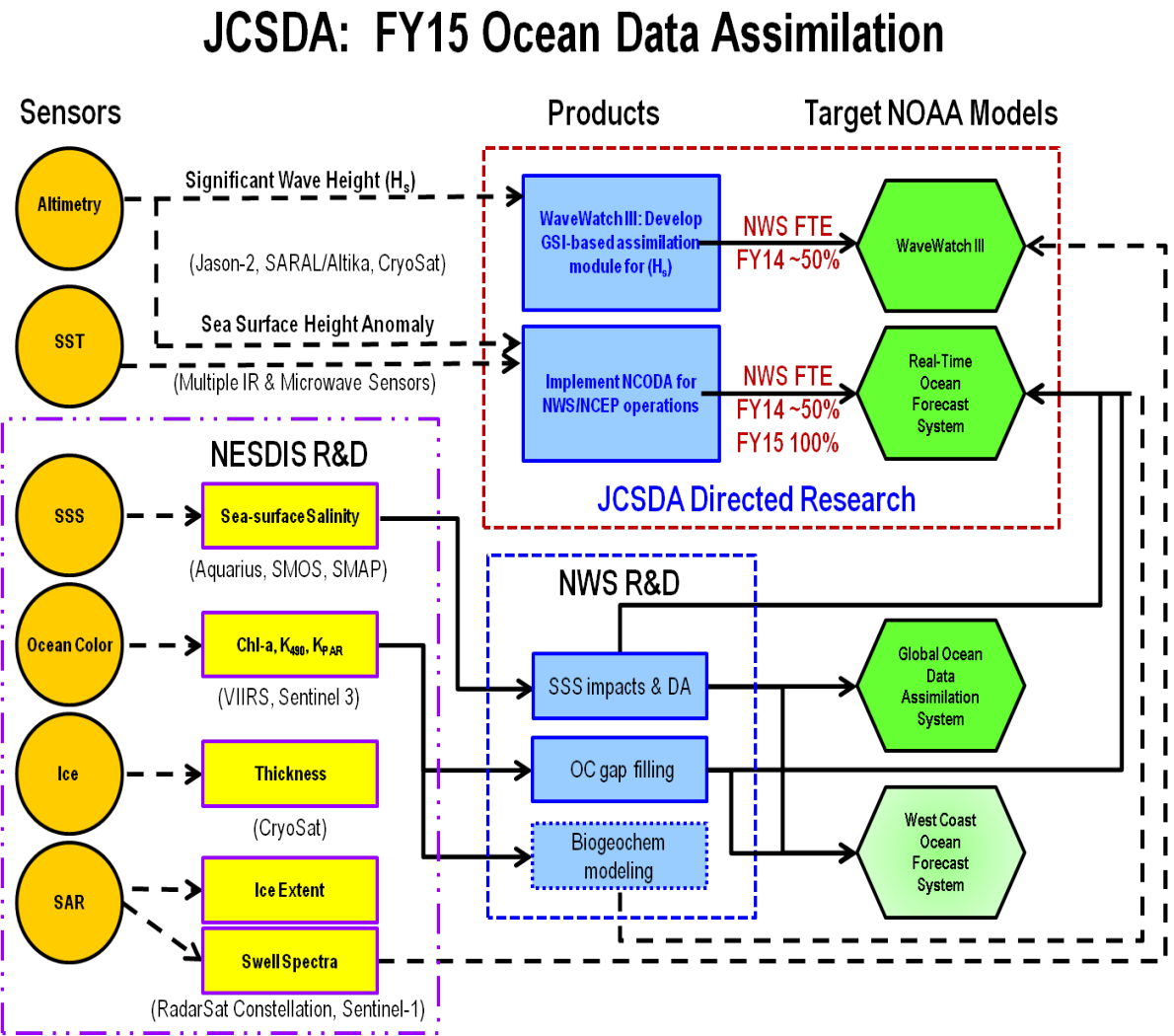
Enhance aerosol capability in Next-Generation Global Prediction System (NGGPS)

Proposed approach:

Tasks	Institutes	Resources (FTE)
Aerosol data assimilation algorithm	GSFC	-- (Leveraging aerosol development at GMAO)
VIIRS observation processing	STAR	0.2
Implementation and testing	NCEP	0.8

Ocean Data Assimilation Coordination

(POCs: NESDIS Eric Bayler- NWS Avichal Mehra)



Objective:

Implement NCODA (Navy's Coupled Ocean Data Assimilation) for NCEP ocean forecasting operations

Sensors/Data:

-SST:

-IR: NOAA & METOP GAC/LAC (AVHRR); VIIRS; COMS; GOES, MTSAT, MSG;
- Microwave: AMSR-E, AATSR, WindSat

- SSS: Aquarius, SMOS

- Sea Ice concentration and temperature:
-AMSR-E, SSMI

- Altimeter SSH: Jason-2, SARAL/AltiKa, CryoSat

- T, S and Velocity profiles from in situ platforms: ARGO, ships, buoys, variety of other profilers

Target models & products:

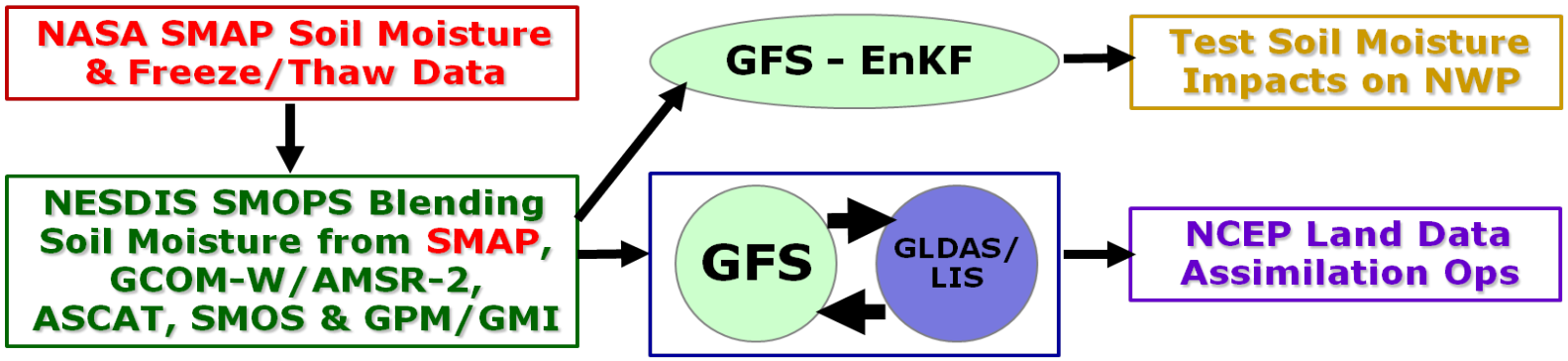
– **Global RTOFS**: SSH; sea-Ice concentrations and drifts; T, S and velocity fields for full 3D ocean.

Land Data Assimilation Coordination

(POCs: NESDIS J. Zhan - NWS M. Ek)

JCSDA Applications of NASA SMAP Data

- Two NOAA SMAP Early Adopters will ingest and assimilation SMAP soil moisture and freeze/thaw data products to improve forecasts of daily rainfall, air temperature, humidity, root-zone soil moisture, skin temperature, runoff and in turn drought and river floods
- NESDIS will ingest SMAP data through Soil Moisture Operational Product System (SMOPS) as inputs to NWS-NCEP models
- NWS-NCEP has tested a GFS-EnKF coupled system to test impact of assimilating satellite soil moisture data on numerical weather prediction (NWP)
- NWS-NCEP and NESDIS-STAR will collaborate on the development of a GFS-GLDAS/LIS semi-coupled system for operational land data assimilation



Backups

Accomplishments - CRTM

CRTM Mission

- Satellite radiance simulation and assimilation for passive MW, IR, & Visible sensors of NOAA,NASA,DoD satellites, and others (200 sensors)
- Simulation of clear/cloudy/precipitating scenes, globally

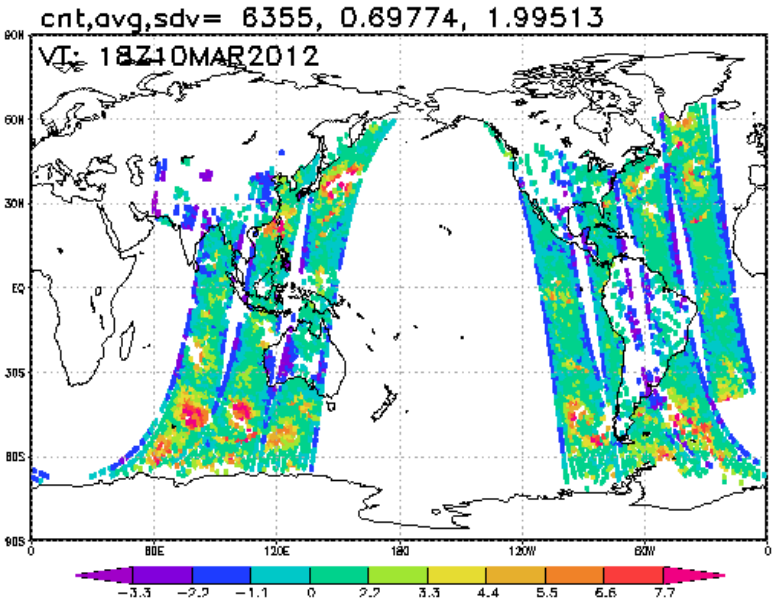
CRTM Applications

- Data assimilation in supporting of weather forecasting
- Physical retrieval algorithm for products
- Stability and accuracy monitoring of satellite observations
- Education and Research: reanalysis, climate studies, air quality forecasting, and a radiative tool for students

CRTM Future Development

- Aquarius, SMOS, SMAP, ..
- CRTM for CMAQ
- CRTM unapodized capability
- CRTM for cloudy/rainy data assimilation

ATMS Ch. 4 (O-B) GDAS

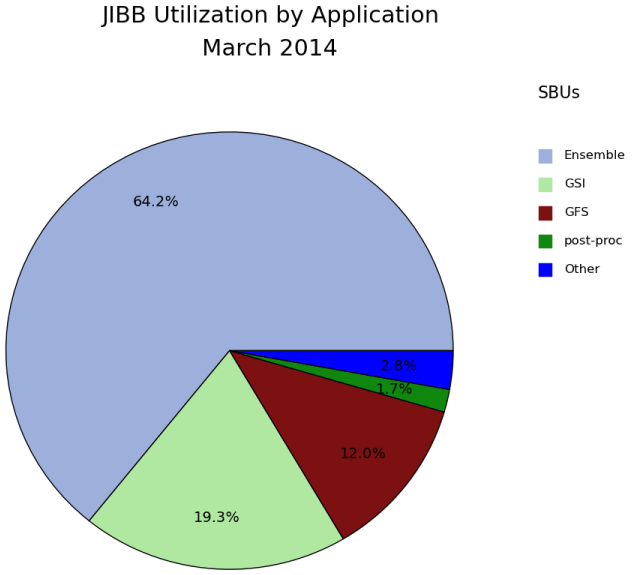


(slide based on Q. Liu presentation)

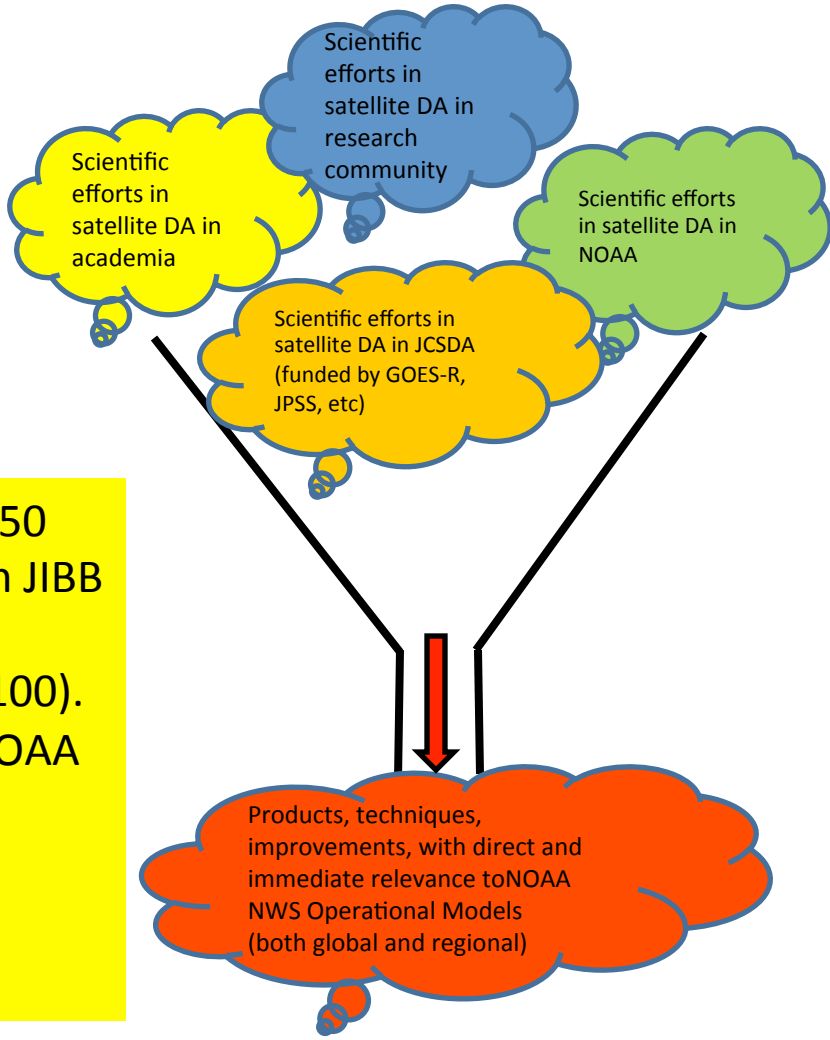
O2R Environment

A pre-requisite for a successful R2O Transition

- **This is a critical piece for a successful R2O. O2R involves:**
  - Supercomputer(s) : JIBB, S4, Zeus Allocation
  - Porting/benchmarking codes/systems/libraries
  - Documentation to help researchers navigate
  - User Support
- **Status:**
  - GSI, GFS implemented/benchmarked
  - HWRF implemented and benchmarked
  - Synchronization with T1534 completed
  - On-going porting of the 4D Hybrid
  - JCSDA secured an upgrade to its JIBB and S4 supercomputers to perform OSSEs/ OSEs and to keep up with the newest resolution
  - JCSDA secured an increase to its NOAA R&D allocation for this year on Zeus (1million core hours) to allow contribution to the H. Sandy data gap mitigation effort. *[yet to be implemented]*
- **In progress:**
  - Extension of O2R to include Ocean DA (NCODA, HYCOM)
  - Extension of O2R to include Land Systems (LIS).

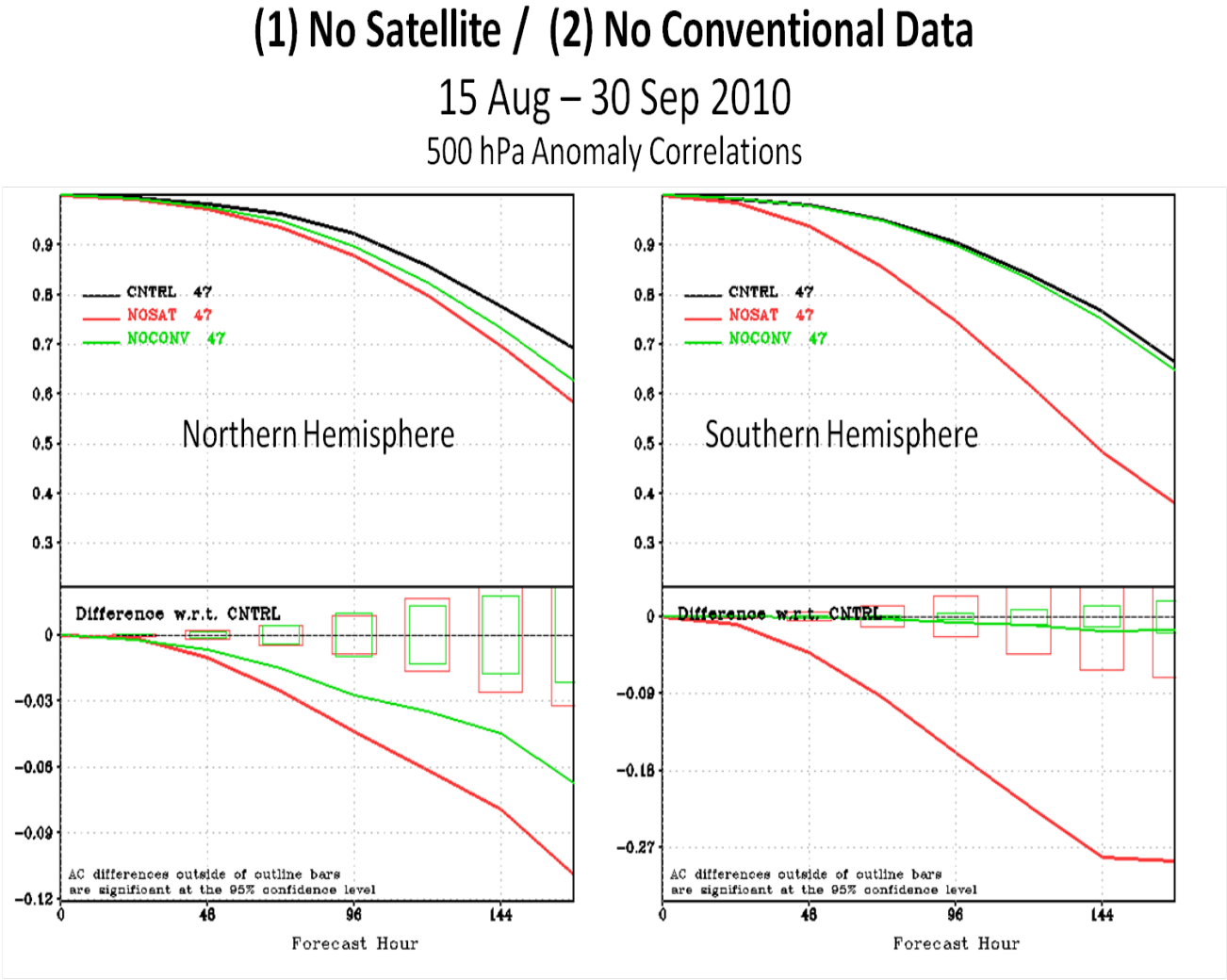


More than ~ 50 users on both JIBB and S4 (total more than ~100). Mixture of NOAA and external Researchers



OSE Activities / Impact Assessment

- An extensive assessment of the global observing system impact on NOAA forecast system has been undertaken.
- The impact assessment was done wrt satellite data (collectively &individually: microwave AMSU, MHS, GPS, hyperspectral IR, AMVs, etc) as well as conventional data.
- Satellite data as a group, had a very significant impact which surpasses the conventional data impact (by a wide margin), especially in the southern hemisphere.
- The impacts of individual classes of sensors did not add up to the significant impact above.



Results from the extensive data denials experiments performed in the JCSDA, aimed at assessing the impact of the global Plots courtesy of J. Jung.